Comparison three interpolation methods for statistical downscaling of GCMs

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1. INTRODUCTION

Climate change could cause significant impacts on water resources by resulting changes in the hydrological cycle. Precipitation is one of the pertinent parameters that influence hydrological cycle as an impact from climate change. The Global Climate Models (GCMs) were used to estimate the projection of climate change. However, The GCMs' outputs cannot be used directly for climate change studies and do not provide a direct estimation of the hydrological response to climate change (Willems & Vrac, 2011). It is due to the mismatch in the spatial resolution between the coarse resolutions of GCMs. Statistical downscaling is one of the methods for obtaining the finer resolution of GCMs output (Lafon *et al.*, 2013). However, statistical downscaling requires the interpolation of GCMs grid to the coordinate of observation station (Okkan & Kirdemir, 2016). The objective of this study is to compare the interpolation methods for the statistical downscaling purpose.

2. METHODOLOGY AND DATASET

The study employed 2013 precipitation data of the second Modern-Era Retrospective analysis for Research and Applications (MERRA-2), which has the resolution of latitude 0.5^{O} and longitude 0.625^{O}. We interpolated the data to be a resolution with latitude 0.0125^{O} and longitude 0.0125^{O}.

The study also used three interpolation methods, namely: Inverse Distance Weights (IDW), Kriging Spherical (KS) and Kriging Gaussian (KG). IDW calculated the unknown points with a weighted average of the values available at the known points (Shepard, 1968) as shown in equation 1.

$$P_x = \frac{\sum_{i=1}^{n} w_i P_i}{\sum_{i=1}^{n} w_i}, \ \ where\ w_i = \frac{1}{{d_i}^{pw}} \quad (1)$$

Where, P_x is interpolated precipitation (mm), P_i is the known precipitation points, w_i is weighting factor, and d_i is the distance between the interpolated point and known points.

Kriging methods not only consider the distance but also the information of known points for estimating the value of unknown point (Luo *et al.*, 2008). The first step in kriging use the sample data to describe the spatial variation, which show in the form of a semivariogram using equation 2.

$$\gamma(h) = \frac{1}{2\,|N(h)|} \sum_{N(h)} (P_i - P_j) \quad (2)$$

Where $N(h)$ is the set of all pairwise Euclidean distances $i - j = h$, $|N(h)|$ is the number of distinct pairs in $N(h)$, and P_i and P_j are data values at spatial location i and j ,respectively. Subsequently, we uses the mathematical functions, which has best fits with the semivariogram. This study used Spherical and Gaussian function as shown in equation 3 and 4, respectively.

$$\left.\begin{aligned} \gamma(h) &= c\left(\frac{3h}{2a} - \frac{1}{2}\left(\frac{h}{a}\right)^3\right) && 0 \le h \le a \\ \gamma(h) &= c && h > a \end{aligned}\right\} \quad (3)$$

$$\gamma(h) = c\left(1 - exp\left(-\frac{h^2}{a^2}\right)\right) \quad 0 \le h \quad (4)$$

Where, $\gamma(h)$ is the spatial variance in h distance, c is the covariance of known point data, h is the distance (m) and a is the range (m).

Thereafter, Kriging calculated the unknown point using equation 5, whereas the weighting factors were calculated using ordinary kriging as shown in equation 6.

$$P_x = \sum_{i=1}^{N} \lambda_i P_i \quad (5)$$

$$A^{-1}.b = \begin{bmatrix} \lambda \\ \phi \end{bmatrix} \quad (6)$$

Where A is the matrix of semivaraินces between of pairs of data points, b is the vector of semivariances between each data point and the point to be predicted, λ is the vector of weights and ϕ is a Lagrangian for solving the equations.

3. RESULTS

Figure 1 shows the comparison of original data and the interpolation results for a one-day event of the dataset. In IDW result shows "bull's eye effects" were produced. While both Kriging methods give more smother results in spatial distribution. The study also interpolated all days of the dataset and subsequently calculated the root mean square error (RMSE) and Nash-Sutcliffe efficiency (NSE) as shown in Table 1.

Table 1. Comparison of validation parameters

Parameter	IDW	KS	KG
RMSE	0.912	0.167	0.172
NSE	0.998	0.999	0.999

4. CONCLUSIONS AND DISCUSSION

The results show all interpolation give acceptable values of validation parameters (Moriasi *et al.*, 2007). Furthermore, both of Kriging methods produced smother results in spatial distribution. However, in some cases, the Kriging produce the negative weighting values (Deutsch, 1996). The problem also was happened in this study, which interpolation results of particular day and location give negative values. Therefore, selecting interpolation methods should also consider the potential mistakes in calculation, such as negative values. Moreover, the further research should consider the other parameter that can influence the interpolation results, such as the altitude and wind direction.

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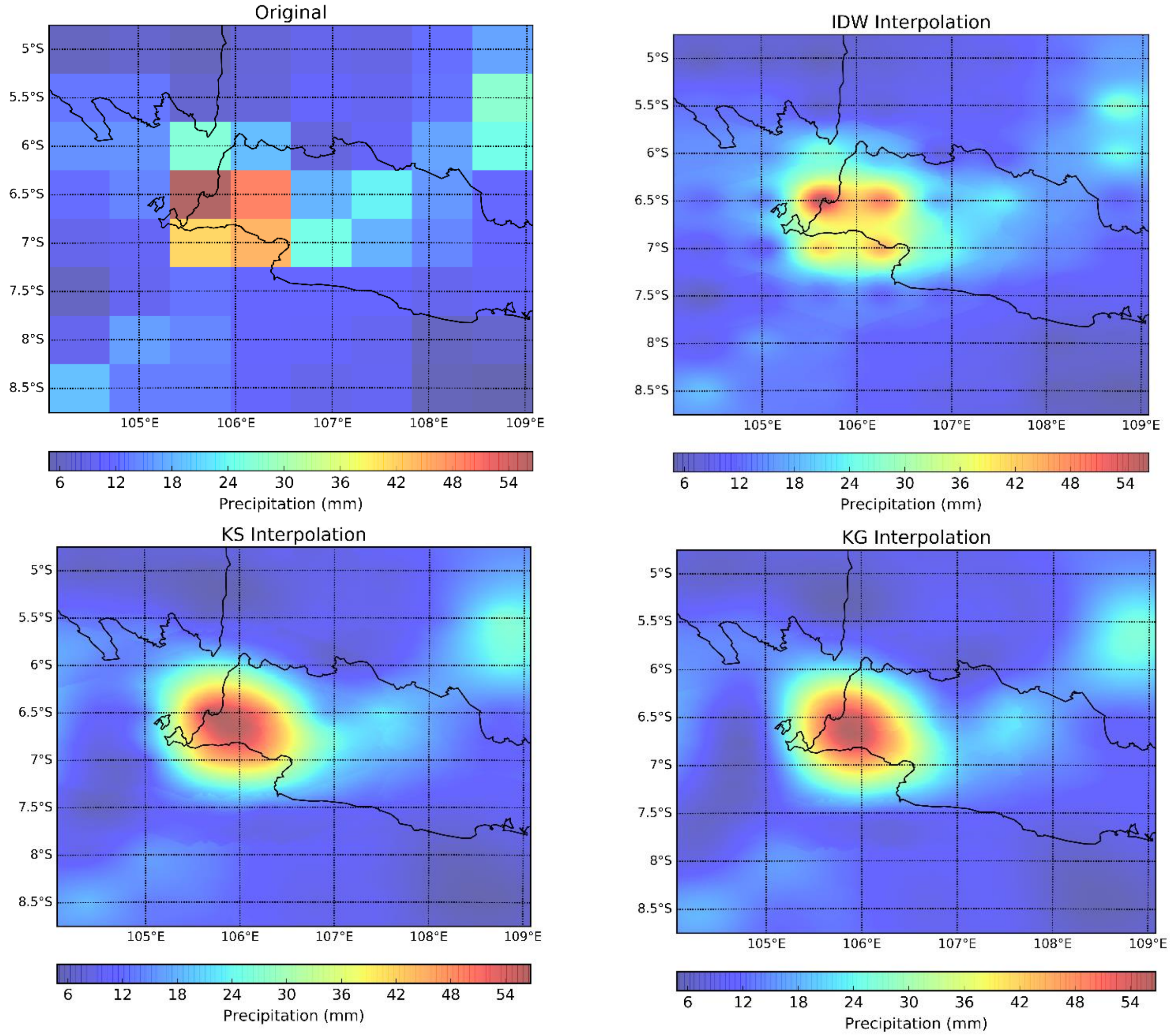

Figure 1. Spatial comparison among the raw data and interpolation results.

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